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(54) Title: READING TUTORIAL SYSTEM

(57) Abstract

A system including a text memory (24) having stored therein digital information representing a given reading text having indices at a plurality of text-locations, a sound memory (22) having stored therein digital information representing a prerecorded speech corresponding to the given text and having indices at a plurality of speech-locations corresponding, respectively, to the plurality of text-locations, a main processor (26) associated with the sound memory and the text memory which correlates between the speech-indices and the text-indices such that each text-location and its respective speech-location are substantially simultaneously addressable, a sound processor (32) associated with the main processor which processes digital information from the sound memory and provides an output corresponding to a reproduction of the prerecorded speech, a sound producing unit (36) which plays-back the reproduced speech to a user and a rate controller (30) associated with the sound processor which controls the rate at which the speech is reproduced, wherein the sound processor maintains the pitch of the reproduced speech substantially the same as the pitch of the prerecorded speech.

READING TUTORIAL SYSTEM

FIELD OF THE INVENTION

The present invention relates to reading aids in general and, more particularly, to devices and methods for playing back sound information corresponding to a written text.

BACKGROUND OF THE INVENTION

Reading accompanied by audible speech corresponding to a text being read is known to be helpful in developing reading skills, particularly for elementary school children reading for the first time and for children having reading disabilities such as dyslexia.

It is appreciated that speech accompaniment is helpful to the reader, since it helps the reader associate the graphemes he reads with their corresponding phonemes.

However, it is inconvenient, expensive and often impossible to provide a child with a personal tutor who will read texts aloud to the child. Therefore, the desired speech information is normally prerecorded on a magnetic tape or the like and played back while the child is reading the corresponding text. Alternatively, the speech may be digitally recorded on a computer memory.

A fundamental problem of this method, however, is that the rate of the played-back speech is rarely consistent with the child's reading rate and, therefore, the above mentioned association between graphemes and phonemes is impaired.

Problems in dealing with reading disabilities are outlined, for example, in "Development of Skill in Reading-while-Listening", by "Margaret L. MacMahon", a Paper presented at the 25th Annual Meeting of the International Reading Association, St. Louis, Missouri, between May 5 and May 9, 1980. The article describes experiments in which speech was played-back at various rates to accompany reading by children of different ages.

The results of these and other experiments indicate that at fast play-back rates children have severe difficulty in following the text, while it is believed that at very slow

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1   play-back rates children tend to be bored with the reading.
2   Additionally, very slow play-back rates are expected to cause
3   inefficient reading habits. It is also appreciated that
4   reading rates vary considerably between children, even within
5   the same age group and, thus, there is no fixed rate which is
6   suitable for every child in a given group. Moreover, even if
7   on the average the speech rate is adapted to the reading rate
8   of a given child, it is not adapted to fluctuations in the
9   child's reading rate, for example due to difficulty in
10 reading certain words and phrases.
11   Playing back of prerecorded audible sounds, such as
12 speech, at a rate different from the original recording rate
13 is known in the art. When the recorded information is simply
14 played-back at a rate faster or slower than the original
15 recording rate, the pitch of the played-back sounds is higher
16 or lower than the original pitch. When the difference in
17 pitch is substantial, the reproduced audible sounds are
18 unpleasant, annoying and sometimes illegible. To overcome
19 this problem, a compensation in pitch is required.
20   U.K. Patent No. 2,229,068 describes a system for
21 playing back prerecorded audible sounds at a rate faster than
22 the original recording rate. The described system provides
23 pitch reduction compensation to maintain the played-back
24 sound substantially at the pitch of the prerecorded sound.
25 The sounds may be played-back at one of a number of discrete
26 rates, wherein appropriate pitch reduction is provided at
27 each rate.
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SUMMARY OF THE INVENTION

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2   The present invention seeks to provide a reading
3   tutorial system which plays-back to a user at a controllable
4   rate prerecorded sound information, preferably speech, while
5   a corresponding reading text is being read by the user.
6   According to the present invention, the prerecorded sound
7   information is played back at a controllable rate, preferably
8   at a rate adapted for the reading rate of the user.
9   Adaptation of the play-back rate to the user's reading rate
10   enables the user to more efficiently associate phonemes of
11   the speech with corresponding graphemes of the text. Regular
12   use of the present tutorial system is expected, in the long
13   run, to improve reading skills of the user, such as
14   phonological awareness and grapheme to phoneme translation
15   ability.

16   In a preferred embodiment of the present invention,
17   information representing the reading text is stored in a text
18   memory, while information representing the corresponding
19   speech is stored in a sound memory. The text and sound
20   memories are preferably both read-only computer memories and
21   the memories are
22   preferably both indexed in accordance with a preselected
23   indexing scheme. According to the present invention, the
24   sound and text memories are correlated such that reference by
25   the user to a given location in one of the memories is
26   accompanied by automatic reference of the system to the
27   corresponding location in the other memory. Thus, for
28   example, when the user selects a location in the text where
29   reading is to begin, the system plays-back the accompanying
30   speech starting from a speech-location corresponding to the
31   selected text-location. Additionally, the correlation between
32   the sound memory and the text memory enables on-line
33   indication of the text location corresponding to the speech
34   location being played-back.

35   According to one aspect of the present invention, the
36   play-back rate is controlled by the user, preferably using a
37   rate control member, such that the sound information is
38   played-back substantially in accordance with the reading rate

1   of the user. According to another aspect of the present
2   invention, the play-back rate is automatically controlled
3   based on predetermined criteria, preferably criteria related
4   to the actual reading rate.
5   There is thus provided in accordance with a preferred
6   embodiment of the invention, a reading tutorial system
7   including:
8   a text memory having stored therein digital
9   information representing a given reading text having indices
10   at a plurality of text-locations;
11   a sound memory having stored therein digital
12   information representing a prerecorded speech corresponding
13   to the given text and having indices at a plurality of
14   speech-locations corresponding, respectively, to the
15   plurality of text-locations;
16   a main processor associated with the sound memory and
17   the text memory which correlates between the speech-indices
18   and the text-indices such that each text-location and its
19   respective speech-location are substantially simultaneously
20   addressable;
21   a sound processor associated with the main processor
22   which processes digital information from the sound memory and
23   provides an output corresponding to a reproduction of the
24   prerecorded speech;
25   a sound producing unit which plays-back the
26   reproduced speech to a user; and
27   a rate controller associated with the sound processor
28   which controls the rate at which the speech is reproduced,
29   wherein the sound processor maintains the pitch of
30   the reproduced speech substantially the same as the pitch of
31   the prerecorded speech.
32   According to one preferred embodiment of the
33   invention, the rate controller is controlled manually by the
34   user to provide a desired play-back rate. The play-back rate
35   may be selected from a plurality of discrete rates or the
36   play-back rate may be continuously selectable.
37   According to another preferred embodiment of the
38   invention, the rate controller includes eye-tracking

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1   apparatus which determines the actual reading rate of the
2   user and wherein the play-back rate is automatically adapted
3   to the actual reading rate.
4   In a preferred embodiment, the system further
5   includes a display for displaying the reading text to the
6   user. The display preferably includes a visual indicator
7   which indicates to the user the text-location corresponding
8   to a speech-location currently being played-back.
9   In a preferred embodiment, the sound processor
10 includes a digital signal processor.
11   According to a preferred embodiment of the invention,
12 for a given played-back speech rate, the processing rate of
13 the sound processor varies in accordance with predetermined
14 criteria dependent on characteristics of the prerecorded
15 speech. Preferably, for played-back speech rates higher than
16 the prerecorded speech rate, information representing
17 consonants is processed at a rate lower than the processing
18 rate of information representing vowels, and, for played-back
19 speech rates lower than the prerecorded speech rate,
20 information representing consonants is processed at a rate
21 higher than the processing rate of information representing
22 vowels.
23   In accordance with an alternative, preferred,
24 embodiment of the present invention, there is provided a
25 reading tutorial system including:
26   a text memory having stored therein digital
27 information representing a given reading text having indices
28 at a plurality of text-locations;
29   a sound memory including a plurality of speech files,
30 each speech file having stored therein digital information
31 representing a digital reproduction of a prerecorded speech
32 corresponding to the given text and having indices at a
33 plurality of speech-locations corresponding, respectively, to
34 the plurality of text-locations;
35   a main processor associated with the sound memory and
36 the text memory which correlates between the speech-indices
37 and the text-indices such that each text-location and its
38 respective speech-location in any of the speech files are

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1   substantially simultaneously addressable;

2   a rate selector associated with the sound processor

3   which selects the speech file from which the reproduced

4   speech is to be played back; and

5   a sound producing unit which plays-back the

6   reproduced speech to a user,

7   wherein each of the speech files defines a different,

8   predetermined, reproduced speech rate.

9   According to one variation of this embodiment of the

10 invention, each speech file is a preprocessed speech file

11 containing a digital reproduction of the prerecorded speech

12 at a different, predetermined, respective, reproduced speech

13 rate but at substantially the same pitch, and wherein all the

14 speech files are reproduced from the same prerecorded speech.

15   According to another variation of this embodiment of

16 the invention, each speech file contains a digital

17 reproduction of a different, respective, prerecorded speech

18 having a predetermined, respective, prerecorded speech rate.

19   In either of the above variations, the rate selector

20 is preferably controlled manually by the user to provide a

21 desired reproduced speech rate.

22   In one preferred embodiment of the present invention,

23 the sound memory and the text memory are both contained in a

24 single read-only-memory (ROM) unit. Preferably, the ROM unit

25 includes a CD-ROM unit. The CD-ROM unit preferably includes

26 an optical disc.

27   In another preferred embodiment of the invention, the

28 sound memory and the text memory are both contained in a

29 multi-user accessible memory unit.

30   Further, in accordance with a preferred embodiment of

31 the present invention there is provided a method for

32 assisting a user in reading a given reading text including

33 the steps of:

34   storing digital information representing the given

35 reading text indexed at a plurality of text-locations;

36   storing digital information representing a

37 prerecorded speech corresponding to the given text with

38 indices at a plurality of speech-locations corresponding,

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1   respectively, to the plurality of text-locations;

2   correlating between the speech-indices and the text-

3   indices such that each text-location and its respective

4   speech-location are substantially simultaneously addressable;

5   processing digital information from the sound memory

6   and providing an output corresponding to a reproduction of

7   the prerecorded speech;

8   playing-back the reproduced speech to the user;

9   controlling the rate at which the speech is

10   reproduced; and

11   maintaining the pitch of the reproduced speech

12   substantially the same as the pitch of the prerecorded

13   speech.

14   According to one preferred embodiment of the

15   invention, the step of controlling the play-back rate

16   includes the step of manually controlling the play-back rate.

17   Preferably, the step of manually controlling the play-back

18   rate includes the step of selecting the play-back rate from a

19   plurality of discrete rates. Alternatively, the play-back

20   rate is continuously selectable.

21   According to another preferred embodiment of the

22   invention, the step of controlling the play-back rate

23   includes the steps of determining the actual reading rate of

24   the user and automatically adapting the play-back rate to the

25   actual reading rate. Preferably, the step of determining the

26   actual reading rate includes the step of tracking the eye

27   movement of the user.

28   In a preferred embodiment of the invention, the

29   method further includes the step of displaying the reading

30   text to the user. Preferably, the step of displaying includes

31   the step of visually indicating to the user the text-location

32   corresponding to a speech-location currently being played-

33   back.

34   The method of the present invention may be used for

35   teaching reading, for assisting reading of users having an

36   eyesight disability, for assisting the reading of users

37   having a reading disability and for teaching languages.

38   In a preferred embodiment, the method further

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1   includes the step of supervising the user by determining
2   whether the user follows the text and the speech. The step of
3   supervising preferably includes the steps of introducing
4   occasional inconsistencies between the text and the speech
5   and determining whether the inconsistencies are detected by
6   the user.
7   In an additionally preferred embodiment of the
8   present invention, the step of playing-back the reproduced
9   speech includes the step of playing-back the reproduced
10 speech at a predetermined volume level which excites the user
11 phonologically and semantically.
12   In a preferred embodiment of the invention, the step
13 of correlating between the speech-indices and the text-
14 indices includes the step of addressing a speech-location
15 corresponding to a text-location selected by the user.
16 Additionally or alternatively, in a preferred embodiment, the
17 step of correlating between the speech-indices and the text-
18 indices includes the step of addressing a text-location
19 corresponding to a given speech-location.
20   In accordance with an alternative embodiment of the
21 present invention, there is provided a method for assisting a
22 user in reading a given reading text including the steps of:
23   storing digital information representing the given
24 reading text indexed at a plurality of text-locations;
25   storing a plurality of speech files, each speech file
26 containing digital information representing a reproduction of
27 a prerecorded speech corresponding to the given text and each
28 speech file having indices at a plurality of speech-locations
29 corresponding, respectively, to the plurality of text-
30 locations;
31   correlating between the speech-indices and the text-
32 indices such that each text-location and its respective
33 speech-location in any of the speech files are substantially
34 simultaneously addressable;
35   selecting the speech file from which the reproduced
36 speech is to be played back; and
37   playing-back the reproduced speech to the user,
38   wherein each speech file defines a different,

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1   respective, reproduced speech rate.

2   One variation of this embodiment of the invention,
3   further includes, in order to create each speech file, the
4   step of preprocessing the prerecorded speech at a different,
5   predetermined, respective, reproduced speech rate but at
6   substantially the same pitch, wherein all the speech files
7   are preprocessed from the same prerecorded speech.

8   Another variation of this embodiment of the invention
9   further includes, in order to create each of the speech
10 files, the step of digitally reproducing a different,
11 respective, prerecorded speech having a predetermined,
12 respective, prerecorded speech rate.

13   In accordance with a further, preferred, embodiment
14 of the present invention, there is provided a read-only-
15 memory (ROM) including:

16   a text memory having stored therein digital
17 information representing a given reading text having indices
18 at a plurality of text-locations; and

19   a sound memory having stored therein digital
20 information representing a prerecorded speech corresponding
21 to the given text and having indices at a plurality of
22 speech-locations corresponding, respectively, to the
23 plurality of text-locations.

24   In accordance with another, preferred, embodiment of
25 the present invention, there is provided a read-only-memory
26 (ROM) including:

27   a text memory having stored therein digital
28 information representing a given reading text having indices
29 at a plurality of text-locations; and

30   a sound memory including a plurality of speech files,
31 each speech file having stored therein digital information
32 representing a digital reproduction of a prerecorded speech
33 corresponding to the given text and having indices at a
34 plurality of speech-locations corresponding, respectively, to
35 the plurality of text-locations.

36   In a preferred embodiment of the present invention,
37 the ROM includes a CD-ROM. Preferably, the CD-ROM includes an
38 optical disc.

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BRIEF DESCRIPTION OF THE DRAWINGS

1
2 The present invention will be better understood from
3 the following detailed description of preferred embodiments
4 of the invention, taken in conjunction with the following
5 drawings in which:
6   Fig. 1 is a simplified, pictorial, illustration of a
7 reading tutorial system constructed and operative in
8 accordance with a preferred embodiment of the present
9 invention;
10   Fig. 2 is a schematic block diagram functionally
11 illustrating the system of Fig. 1; and
12   Fig. 3 is a simplified, pictorial, illustration of a
13 reading tutorial system constructed and operative in
14 accordance with an alternative, preferred, embodiment of the
15 present invention.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

16
17   Reference is now made to Fig. 1, which schematically
18 illustrates a reading tutorial system in accordance with a
19 preferred embodiment of the present invention. The system
20 preferably includes a central processing unit (CPU) 10
21 associated with a display 12 and a mouse 14 as known in the
22 art. In a preferred embodiment of the present invention, the
23 system further includes a sound producing device associated
24 with CPU 10 and preferably including a head-set 20 adapted
25 for a user 18. According to one embodiment of the present
26 invention the system also includes a rate control pedal 16
27 operated by user 18 as described below.
28   During operation of the system, user 18 reads a
29 preselected text which is preferably displayed on display 12.
30 A curser or other movable visual indicator, which may be
31 controlled by mouse 14 or using a keyboard as known in the
32 art, is preferably displayed together with the text on
33 display 12. According to the present invention, a speech
34 corresponding to the text being read by user 18 are played-
35 back to the user via head-set 20 at a rate controlled by user
36 18 using rate controller 16. In a preferred embodiment of the
37 invention, the curser or other visual indication moves along
38 the text on display 12 according to the rate of the played-

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1   back speech.

2   Reference is now made to Fig. 2 which functionally
3   illustrates the system of Fig. 1. As shown in Fig. 2, the
4   system preferably includes a sound memory 22 and a text
5   memory 24, both of which are associated with a central
6   processing unit (CPU) 26 which addresses the information
7   stored in the memories. Memories 22 and 24 may be physically
8   embodied in two, separate, digital memory units or in a
9   single memory unit, as known in the art. Since the
10   information stored in memories 22 and 24 is preferably fixed,
11   read-only-memories (ROM) are preferably used, inter alia, to
12   prevent user 18 from changing the stored information
13   intentionally or accidentally. CPU 26 is preferably
14   associated with a visual display 34 which displays the
15   processed reading text and, via a digital signal processor
16   (DSP) 32 and a digital-to-analog (D/A) converter 33, with a
17   sound producing unit 36 which generates an audible
18   reproduction of the prerecorded speech. Sound producing unit
19   36 is preferably associated with head-set 20 of user 18.
20   Display 34 preferably includes a computer screen as indicated
21   by reference numeral 12 in Fig. 1.

22   Text memory 24 is used for storing digital
23   information representing a given reading text, such as the
24   content of a book, an essay or a reading exercise. According
25   to a preferred embodiment of the invention, the text stored
26   in memory 24 is indexed at preselected locations so as to
27   enable access by CPU 26 to given locations of the text stored
28   in memory 24. Any suitable indexing scheme may be used, for
29   example indices may be provided at the beginning of each
30   letter, syllable, word or sentence, so as to achieve a
31   predetermined resolution in accessing the stored text.

32   In accordance with a preferred embodiment of the
33   present invention, sound memory 22 is used for storing
34   digital information representing a prerecorded speech
35   corresponding to the text stored in text memory 24. The
36   speech stored in memory 22 is preferably indexed in
37   accordance with the indexing scheme used for the text in
38   memory 24. For example, if the information in memory 24 is

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1   indexed at the beginning of each word of the text, the
2   information in memory 22 is preferably indexed at the
3   beginning of each, respective, word of the corresponding
4   prerecorded speech.

5   As mentioned above, memories 22 and 24 may be
6   embodied in separate memory units or both memories may be
7   included in a single memory unit, preferably a read-only-
8   memory (ROM) unit. In accordance with one preferred
9   embodiment of the present invention, the speech information
10 of memory 22 and the text information of memory 24 are both
11 stored on a single CD-ROM unit, preferably including a
12 compact optical disc. It should be appreciated that such CD-
13 ROM units are capable of storing large volumes of speech and
14 text information. The speech and text information stored on
15 the CD-ROM unit is preferably indexed as described above.

16   In accordance with another preferred embodiment of
17 the present invention, the speech information of memory 22
18 and the text information of memory 24 are part of a central
19 memory unit, such as a data-base. In this preferred
20 embodiment of the invention, the speech and text information
21 may be retrieved from the central memory unit by multiple
22 users, using any known computer communication system or
23 network. For example, the speech and text information may be
24 stored in a data-base connected to InterNet.

25   During operation, CPU 26 reads text information from
26 memory 24 and corresponding speech information from memory
27 22. Pointer circuitry in CPU 26 correlates between the
28 indices of the text information and the corresponding indices
29 of the sound information, such that respective indices of
30 memories 22 and 24 may be addressed simultaneously. When CPU
31 26 is directed by user 18 to address a desired location in
32 the text, as described below, the above mentioned pointer
33 circuitry also addresses the corresponding location in the
34 speech to be played-back.

-35   As further shown in Fig. 2, CPU 26 is associated with
36 a rate controller 30 which may be foot-operated, as shown by
37 reference numeral 16 in Fig. 1, or hand-operated, for
38 example, through appropriately defined functions of mouse 14

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1   (Fig. 1). A analog-to-digital (A/D) converter is preferably
2   employed to convert the generally analog output of rate
3   controller 30 to a corresponding digital output readable by
4   CPU 26. In accordance with the present invention, CPU 26
5   controls the rate of data processing by DSP 32 based on the
6   input from rate controller 30. For example, in the embodiment
7   of Fig. 1, the position of pedal 16 controls the output of
8   the pedal and, thus, controls the processing rate of sound-
9   bearing data by DSP 32.

10   As known in the art, DSP 32 processes the sound-
11 bearing digital data and D/A 33 generates a corresponding
12 analog output to sound producing unit 36. The circuitry of
13 sound producing unit 36 may include amplifiers, filters,
14 etc., as required for reproducing the prerecorded speech
15 through speakers (not shown) and/or head-set 20 (Fig. 1). It
16 should be appreciated that the play-back rate of the
17 reproduced speech is determined by the rate at which sound-
18 bearing data is processed by DSP 32 and, therefore, the play-
19 back rate is controlled by user 18 using rate controller 30.

20   The data output rate of DSP 32 varies in accordance
21 with the desired play-back rate, such that the data output
22 rate is higher for higher play-back rates and lower for lower
23 play-back rates. Alternatively, if DSP 32 is designed to
24 output digital information at a given rate, down-sampling of
25 the sound-bearing digital data, i.e. processing of only part
26 of the digital data, may be used for play-back rates higher
27 than the original speech rate.

28   To maintain the desired data output rate for play-
29 back rates lower than the original speech rate, DSP 32
30 preferably up-samples the sound-bearing digital data, i.e.
31 generates additional samples which may be duplicates of
32 adjacent existing samples or otherwise dependent on existing
33 samples. If up-sampling is not used, the data output rate of
34 DSP 32 varies in accordance with the desired play-back rate.

35   It is appreciated that, in natural speech, changes in
36 rate may be inhomogeneous, e.g. the time-span of vowels is
37 generally more dependent on the speech rate than the time
38 span of consonants. Thus, in a preferred embodiment of the

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1 present invention, changes in played-back speech rate are
2 not homogeneous. For example, changes in the processing rate
3 of data strings representing consonants may be different
4 from, and generally proportionally lower than, changes in
5 the processing rate of data strings representing vowels. To
6 distinguish between different speech elements, such as vowels
7 and consonants, the corresponding data-strings may be marked
8 to indicate the appropriate changes in processing rate
9 required for each data-string.

10   It is appreciated, however, that the pitch of the
11 played-back speech varies with the play-back rate, i.e. the
12 higher the play-back rate the higher the pitch. Thus,
13 according to the present invention, the pitch of the played-
14 back speech is controlled in accordance with the play-back
15 rate. The pitch is preferably controlled by pitch
16 compensation circuitry which receives from CPU 26 a pitch
17 control input responsive to the play-back rate and provides
18 appropriate pitch compensation. Since the required change in
19 pitch is uniquely determined by the change in play-back-rate,
20 pitch compensation may be based on a predetermined formula
21 executed by the pitch compensation circuitry, as known in the
22 art. The pitch compensation circuitry may be included in DSP
23 32, as shown in Fig. 2, or it may be provided in a separate
24 unit preceding or following DSP 32.

25   A preferred sequence of operation of the present
26 tutorial system will now be described, referring also to Fig.
27 1. User 18 uses mouse 14 to select a preselected portion of
28 the reading text to appear on display 34. The exact location
29 from which reading is to begin is preferably highlighted or
30 otherwise distinguished on display 34 as known in the art.
31 The pointer circuitry of CPU 26 identifies the index of the
32 selected location in text memory 24 and addresses the
33 corresponding index in speech memory 22. Thus, the
34 prerecorded speech is played-back starting from the location
35 selected by user 18. In a preferred embodiment of the
36 invention, the highlighted location in the displayed text,
37 which may be a letter, a syllable, a word, etc., moves in
38 accordance with the play-back rate of the corresponding

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1   speech.

2   It should be appreciated that due to the indexing
3   scheme which correlates between memories 22 and 24, user 18
4   can use mouse 14 to "hop" to any desired location in the
5   text, preceding or succeeding the initial location, while
6   listening to the corresponding speech location after each
7   "hop".

8   If the initial play-back rate is unsuitable for user
9   18, i.e. too fast or to slow, user 18 changes the play back
10 rate using rate controller 30. The pitch of the played-back
11 speech is preferably substantially constant, due to the
12 automatic pitch compensation described above. This,
13 preferably on-line, control of the play-back rate ensures
14 that the prerecorded speech is played-back to the user at a
15 rate adapted for his or her specific reading skills and/or
16 habits.

17   In a preferred embodiment of the invention, rate
18 controller 30 provides continuous rate control. However, in a
19 simpler system, controller 30 may be embodied as a multi-
20 position switch, wherein a plurality of discrete play-back
21 rates are defined by the different switch positions.
22 Alternatively, the play-back rate may be selected from a menu
23 appearing on display 34 using a keyboard (not shown) or mouse
24 14.

25   In an alternative, preferred, embodiment of the
26 present invention, changes in the speech rate and appropriate
27 pitch compensations are performed off-line rather than on-
28 line. According to this embodiment, preprocessed files
29 corresponding to a plurality of different play-back rates of
30 the prerecorded speech are stored separately in speech
31 memory 22. To correlate between the preprocessed files and
32 the text in memory 24, each of the preprocessed files is
33 preferably indexed in accordance with the indexing scheme of
34 text memory 24. At any given time during operation of the
35 system, sound information is retrieved from one of the
36 preprocessed files which corresponds to the play-back rate
37 selected by user 18 from a preselected menu, for example by
38 using a multi-position switch as described above. In a

- 15 -

1   preferred embodiment of the invention, the speech location
2   being played-back is substantially unaffected by changes in
3   the play-back rate, as described below.

4   Since each preprocessed file preferably corresponds
5   to a constant play-back rate, having a predetermined constant
6   ratio relative to the original, prerecorded, speech rate,
7   the ratios between the play-back rates of the different
8   preprocessed files are also constant and predeterminable.
9   Thus, based on a given speech location in a given
10 preprocessed file, it is possible to accurately determine a
11 corresponding speech location in any of the other
12 preprocessed files. For example, if the ratio between the
13 play-back rates of two preprocessed files is 2:1, there is a
14 time ratio of 2:1 between corresponding speech locations of
15 the two files. This time ratio is preferably applied to
16 maintain a correct speech location when the user switches
17 between the different play-back rates.

18   Alternatively, since the same indexing scheme is
19 preferably used for all of the preprocessed files, the
20 indexing of the preprocessed files can be utilized to
21 maintain the correct speech location when the play-back rate
22 is changed by user 18.

23   To obtain the preprocessed files, processing as
24 described above is preferably employed to change the speech
25 rate and to provide appropriate pitch compensation for each
26 file. For example, down-sampling or up-sampling as described
27 above can be used. The preprocessed files are then stored
28 separately in speech memory 22. Therefore, no further
29 processing is required, on-line, to provide the desired play-
30 back rate and appropriate pitch compensation during
31 operation.

32   In a further, preferred, embodiment of the invention,
33 a plurality of prerecordings of the original speech are used
34 for providing the different speech rates, whereby the text is
35 read at a different, preselected, speech rate during each
36 prerecording. The prerecorded speeches are then stored
37 separately in speech memory 22, e.g. in separate files. The
38 provision of a plurality of preselected actual speech rates,

- 16 -

1 at the prerecording stage, obviates the need for processing
2 as in the above embodiments to provide different play-back
3 rates. During operation, the prerecorded speeches are
4 retrieved from speech memory 22, in accordance with the rate-
5 selections of user 18, as described above with reference to
6 the embodiment in which preprocessed files are used. The same
7 indexing scheme is preferably used for all the prerecorded
8 speeches so as to maintain the correct speech location when
9 user 18 switches between different speech rates.
10   According to another preferred embodiment of the
11 present invention, not shown in the drawings, the play back
12 rate is controlled automatically using an eye-tracking
13 system. For example, as shown in Fig. 3, the eye tracking
14 system may include an optical sensor 40, such as a video
15 camera, which follows the movement of the pupils of user 18.
16 The output of optical sensor 40 is preferably processed by
17 appropriate rate-control circuitry in controller 30 or CPU
18 26. According to this embodiment of the invention, user 18
19 simply reads the text while the accompanying speech is
20 automatically played-back at the actual reading rate of the
21 user. Eye-tracking devices as required for this preferred
22 embodiment of the present invention are known in the art.
23   According to a further, preferred, embodiment of the
24 present invention, the reading tutorial system provides means
25 for supervising the user by determining whether the user
26 follows the text and the speech with sufficient
27 concentration. This can be achieved, for example, by
28 introducing occasional inconsistencies between the text and
29 the speech, whereby the user is required to provide a
30 preselected active response each time an inconsistency is
31 detected.
32   Reference is again made to Fig. 2. In a preferred
33 embodiment of the present invention, the sounds produced by
34 sound producing unit 36 are volume-controlled, for example by
35 an appropriate control button on unit 36. According to this
36 preferred embodiment, the speech accompaniment can be played-
37 back at very low volume levels so as to cause subliminal
38 phonological and semantic excitation of the user, as known in

- 17 -

1   the art. With such low volume speech accompaniment, the user

2   is prevented from being fully dependent on the played-back

3   speech during reading.

4   It should be appreciated that use of the present

5   reading tutorial system is not limited to improvement of

6   reading skills among school children. In fact, the present

7   invention may be equally suitable for a variety of other

8   uses,   for example learning of new languages, assisting

9   reading of people having poor eyesight and/or reading

10   disabilities such as dyslexia.

11   Speech memory 22 and text memory 24 may be

12   implemented form of memory known in the art, such information

13   may be stored using any suitable memory. For example, both

14   the text and sound memory

15   It will be appreciated by persons skilled in the art

16   that the present invention is not limited to what has been

17   thus far described. Rather, the scope of the present

18   invention is limited only by the following claims:

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1   C L A I M S
2
3.   1.   A reading tutorial system comprising:
4   a text memory having stored therein digital
5   information representing a given reading text having indices
6   at a plurality of text-locations;
7   a sound memory having stored therein digital
8   information representing a prerecorded speech corresponding
9   to the given text and having indices at a plurality of
10 speech-locations corresponding, respectively, to the
11 plurality of text-locations;
12   a main processor associated with the sound memory and
13 the text memory which correlates between the speech-indices
14 and the text-indices such that each text-location and its
15 respective speech-location are substantially simultaneously
16 addressable;
17   a sound processor associated with the main processor
18 which processes digital information from the sound memory and
19 provides an output corresponding to a reproduction of the
20 prerecorded speech;
21   a sound producing unit which plays-back the
22 reproduced speech to a user; and
23   a rate controller associated with the sound processor
24 which controls the rate at which the speech is reproduced,
25   wherein the sound processor maintains the pitch of
26 the reproduced speech substantially the same as the pitch of
27 the prerecorded speech.
28
29 2.   A system according to claim 1 wherein the rate
30 controller is controlled manually by the user to provide a
31 desired play-back rate.
32
33 3.   A system according to claim 2 wherein the play-back
34 rate is selected from a plurality of discrete rates.
-35
36 4.   A system according to claim 2 wherein the play-back
37 rate is continuously selectable.
38

                                - 19 -

1   5.   A system according to claim 1 wherein the rate
2   controller comprises eye-tracking apparatus which determines
3   the actual reading rate of the user and wherein the play-back
4   rate is automatically adapted to the actual reading rate.
5
6   6.   A system according to any of the preceding claims
7   wherein the sound processor comprises a digital signal
8   processor.
9
10 7.   A system according to any of claims 1-5 wherein, for
11 a given played-back speech rate, the processing rate of the
12 sound processor varies in accordance with predetermined
13 criteria dependent on characteristics of the prerecorded
14 speech.
15
16 8.   A system according to claim 7 wherein, for played-
17 back speech rates higher than the prerecorded speech rate,
18 information representing consonants is processed at a rate
19 lower than the processing rate of information representing
20 vowels, and, for played-back speech rates lower than the
21 prerecorded speech rate, information representing consonants
22 is processed at a rate higher than the processing rate of
23 information representing vowels.
24
25 9.   A reading tutorial system comprising:
26   a text memory having stored therein digital
27 information representing a given reading text having indices
28 at a plurality of text-locations;
29   a sound memory including a plurality of speech files,
30 each speech file having stored therein digital information
31 representing a digital reproduction of a prerecorded speech
32 corresponding to the given text and having indices at a
33 plurality of speech-locations corresponding, respectively, to
34 the plurality of text-locations;
35   a main processor associated with the sound memory and
36 the text memory which correlates between the speech-indices
37 and the text-indices such that each text-location and its
38 respective speech-location in any of the speech files are

- 20 -

1   substantially simultaneously addressable;

2   a rate selector associated with the sound processor
3   which selects the speech file from which the reproduced
4   speech is to be played back; and

5   a sound producing unit which plays-back the
6   reproduced speech to a user,

7   wherein each of the speech files defines a different,
8   predetermined, reproduced speech rate.

9

10   10.   A system according to claim 9 wherein at least one
11   speech file is a preprocessed speech file containing a
12   digital reproduction of the prerecorded speech at a
13   different, predetermined, respective, reproduced speech rate
14   but at substantially the same pitch, and wherein all the
15   speech files are reproduced from the same prerecorded speech:

16

17   11.   A system according to claim 9 wherein at least one
18   speech file contains a digital reproduction of a different,
19   respective, prerecorded speech having a predetermined,
20   respective, prerecorded speech rate.

21

22   12.   A system according to any of claims 9-11 wherein the
23   rate selector is controlled manually by the user to provide a
24   desired reproduced speech rate.

25

26   13.   A system according to any of claims 9-11 and further
27   comprising a display for displaying the reading text to the
28   user.

29

30   14.   A system according to claim 13 wherein the display
31   comprises a visual indicator which indicates to the user the
32   text-location corresponding to a speech-location currently
33   being played-back.

34

35   15.   A system according to any of claims 1-5 or 9-11
36   wherein said sound memory and said text memory are both
37   contained in a single read-only-memory (ROM) unit.

38

- 21 -

1   16.   A system according to claim 15 wherein the ROM unit

2   comprises a CD-ROM unit.

3

4   17.   A system according to claim 16 wherein the CD-ROM

5   unit comprises an optical disc.

6   .

7   18.   A system according to any of claims 1-5 or 9-11

8   wherein said sound memory and said text memory are both

9   contained in a multi-user accessible memory unit.

10

11   19.   A method for assisting a user in reading a given

12   reading text comprising the steps of:

13   storing digital information representing the given

14   reading text indexed at a plurality of text-locations;

15   storing   digital   information   representing   a

16   prerecorded speech corresponding to the given text with

17   indices at a plurality of speech-locations corresponding,

18   respectively, to the plurality of text-locations;

19   correlating between the speech-indices and the text-

20   indices such that each text-location and its respective

21   speech-location are substantially simultaneously addressable;

22   processing digital information from the sound memory

23   and providing an output corresponding to a reproduction of

24   the prerecorded speech;

25   playing-back the reproduced speech to the user;

26   controlling   the   rate   at   which   the   speech   is

27   reproduced; and

28   maintaining   the   pitch   of   the   reproduced   speech

29   substantially   the   same   as   the   pitch   of   the   prerecorded

30   speech.

31

32   20.   A method according to claim 19 wherein the step of

33   controlling the play-back rate comprises the step of manually

34   controlling the play-back rate.

35

36   21.   A method according to claim 20 wherein the step of

37   manually controlling the play-back rate comprises the step of

38   selecting the play-back rate from a plurality of discrete

                                - 22 -

1   rates.

2

3   22.   A method according to claim 21 wherein the play-back
4   rate is continuously selectable.

5

6   23.   A method according to claim 19 wherein the step of
7   controlling the play-back rate comprises the steps of
8   determining the actual reading rate of the user and
9   automatically adapting the play-back rate to the actual
10   reading rate.

11

12   24.   A method according to claim 23 wherein the step of
13   determining the actual reading rate comprises the step of
14   tracking the eye movement of the user.

15

16   25.   A method for assisting a user in reading a given
17   reading text comprising the steps of:
18   storing digital information representing the given
19   reading text indexed at a plurality of text-locations;
20   storing a plurality of speech files, each speech file
21   containing digital information representing a reproduction of
22   a prerecorded speech corresponding to the given text and each
23   speech file having indices at a plurality of speech-locations
24   corresponding, respectively, to the plurality of text-
25   locations;

26   correlating between the speech-indices and the text-
27   indices such that each text-location and its respective
28   speech-location in any of the speech files are substantially
29   simultaneously addressable;
30   selecting the speech file from which the reproduced
31   speech is to be played back; and
32   playing-back the reproduced speech to the user,
33   wherein each speech file defines a different,
34   respective, reproduced speech rate.

35

36   26.   A method according to claim 25 and further
37   comprising, to create each speech file, the step of
38   preprocessing the prerecorded speech at a different,

- 23 -

SUBSTITUTE SHEET (RULE 26)

1 predetermined, respective, reproduced speech rate but at

2 substantially the same pitch, wherein all the speech files

3 are preprocessed from the same prerecorded speech.

4

5 27.   A method according to claim 25 and further

6 comprising, to create each of the speech files, the step of

7 digitally reproducing a different, respective, prerecorded

8 speech having a predetermined, respective, prerecorded speech

9 rate.

10

11 28.   A method according to any of claims 19 - 27 and

12 further comprising the step of displaying the reading text to

13 the user.

14

15 29.   A method according to claim 28 wherein the step of

16 displaying comprises the step of visually indicating to the

17 user the text-location corresponding to a speech-location

18 currently being played-back.

19

20 30.   A method according to any of claims 19 - 27 used for

21 teaching reading.

22

23 31.   A method according to any of claims 19 - 27 used for

24 assisting reading of users having an eyesight disability.

25

26 32.   A method according to any of claims 19 - 27 used for

27 assisting the reading of users having a reading disability.

28

29 33.   A method according to any of claims 19 - 27 used for

30 teaching a language.

31

32 34.   A method according to any of claims 19 - 27 and

33 further comprising the step of supervising the user by

34 determining whether the user follows the text and the speech.

35

36 35.   A method according to claim 34 wherein the step of

37 supervising comprises the steps of introducing occasional

38 inconsistencies between the text and the speech and

- 24 -

SUBSTITUTE SHEET (RULE 26)

1   determining whether the inconsistencies are detected by the
2   user.
3
4   36.   A method according to any of claims 19 - 27 wherein
5   the step of playing-back the reproduced speech comprises the
6   step of playing-back the reproduced speech at a predetermined
7   volume level which excites the user phonologically and
8   semantically.
9
10 37.   A method according to any of claims 19 - 27 wherein
11 the step of correlating between the speech-indices and the
12 text-indices comprises the step of addressing a speech-
13 location corresponding to a text-location selected by the
14 user.
15
16 38.   A method according to any of claims 19 - 27 wherein
17 the step of correlating between the speech-indices and the
18 text-indices comprises the step of addressing a text-location
19 corresponding to a given speech-location.
20
21 39.   A read-only-memory (ROM) comprising:
22   a text memory having stored therein digital
23 information representing a given reading text having indices
24 at a plurality of text-locations; and
25   a sound memory having stored therein digital
26 information representing a prerecorded speech corresponding
27 to the given text and having indices at a plurality of
28 speech-locations corresponding, respectively, to the
29 plurality of text-locations.
30
31 40.   A read-only-memory (ROM) comprising:
32   a text memory having stored therein digital
33 information representing a given reading text having indices
34 at a plurality of text-locations; and
35   a sound memory including a plurality of speech files,
36 each speech file having stored therein digital information
37 representing a digital reproduction of a prerecorded speech
38 corresponding to the given text and having indices at a

- 25 -

1 plurality of speech-locations corresponding, respectively, to
2 the plurality of text-locations.
3
4 41.   A ROM according to claim 39 or claim 40 comprising a
5 CD-ROM.
6
7 42.   A ROM according to claim 41 comprising an optical
8 disc.
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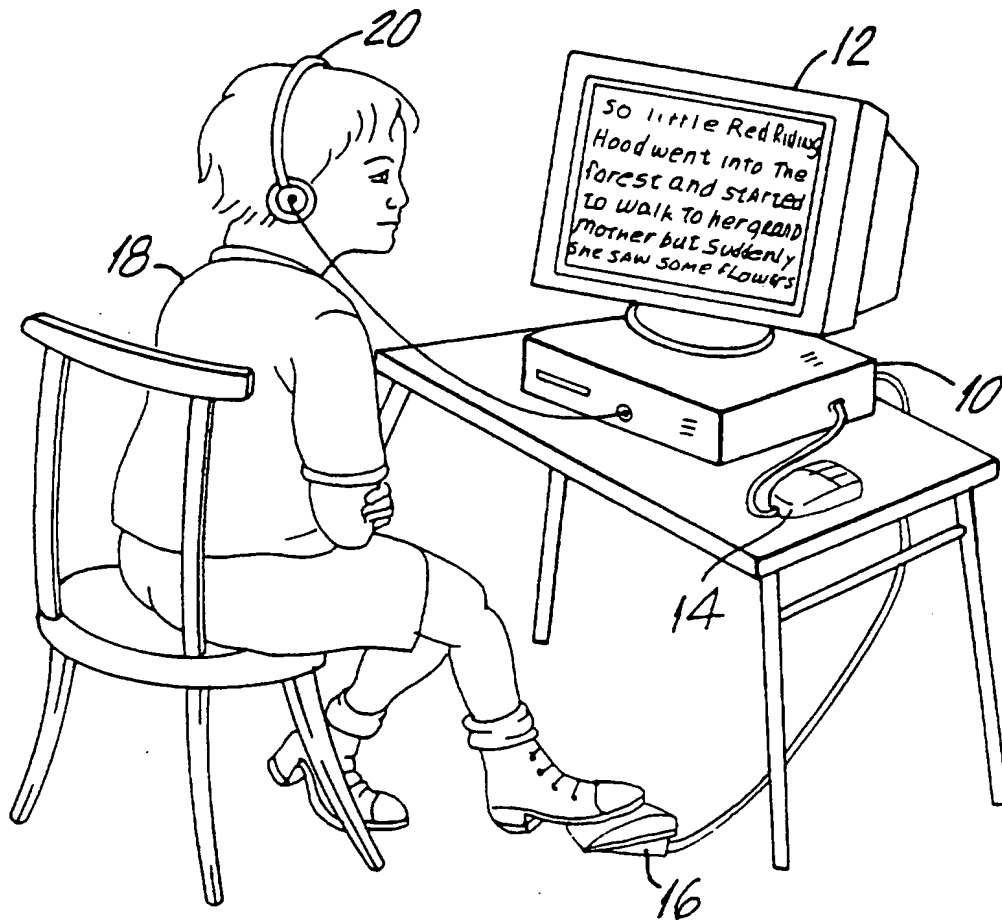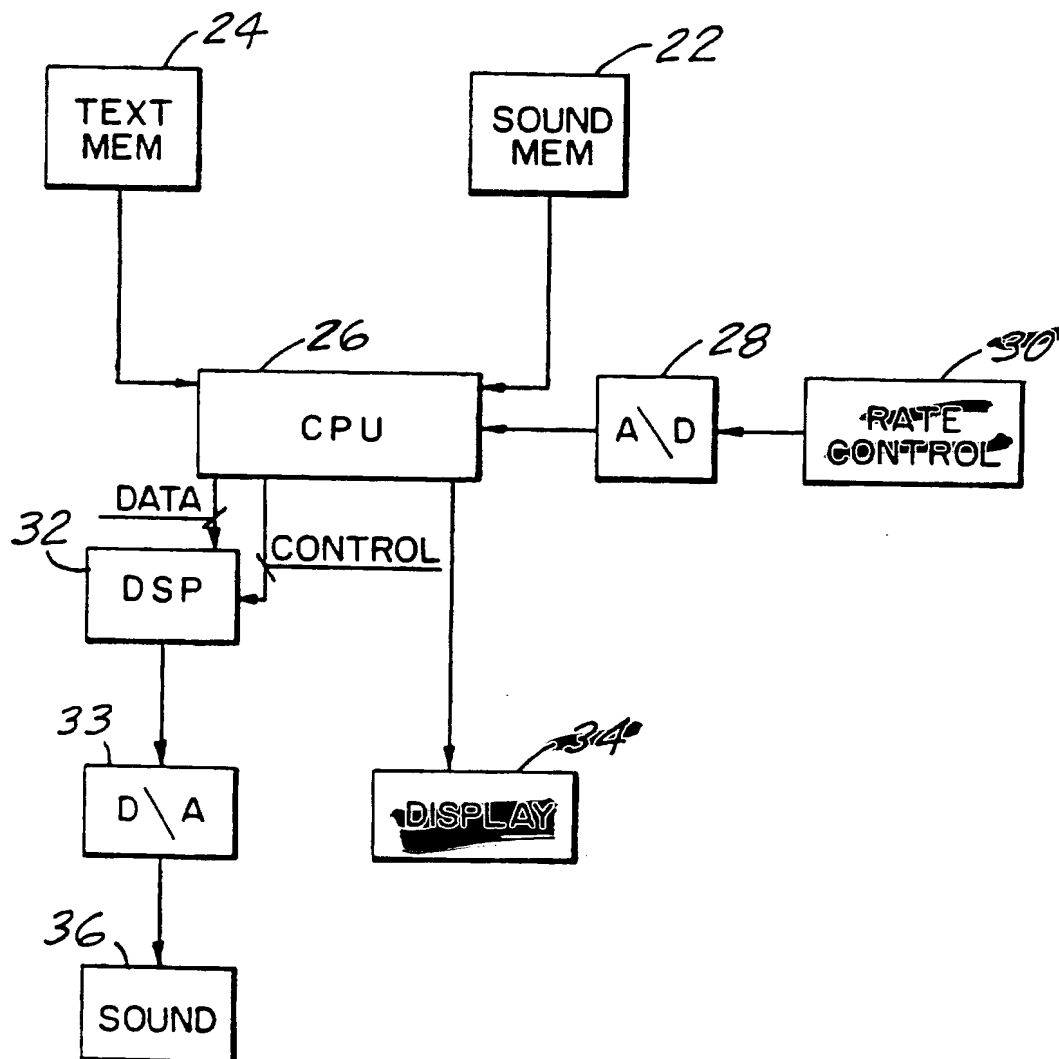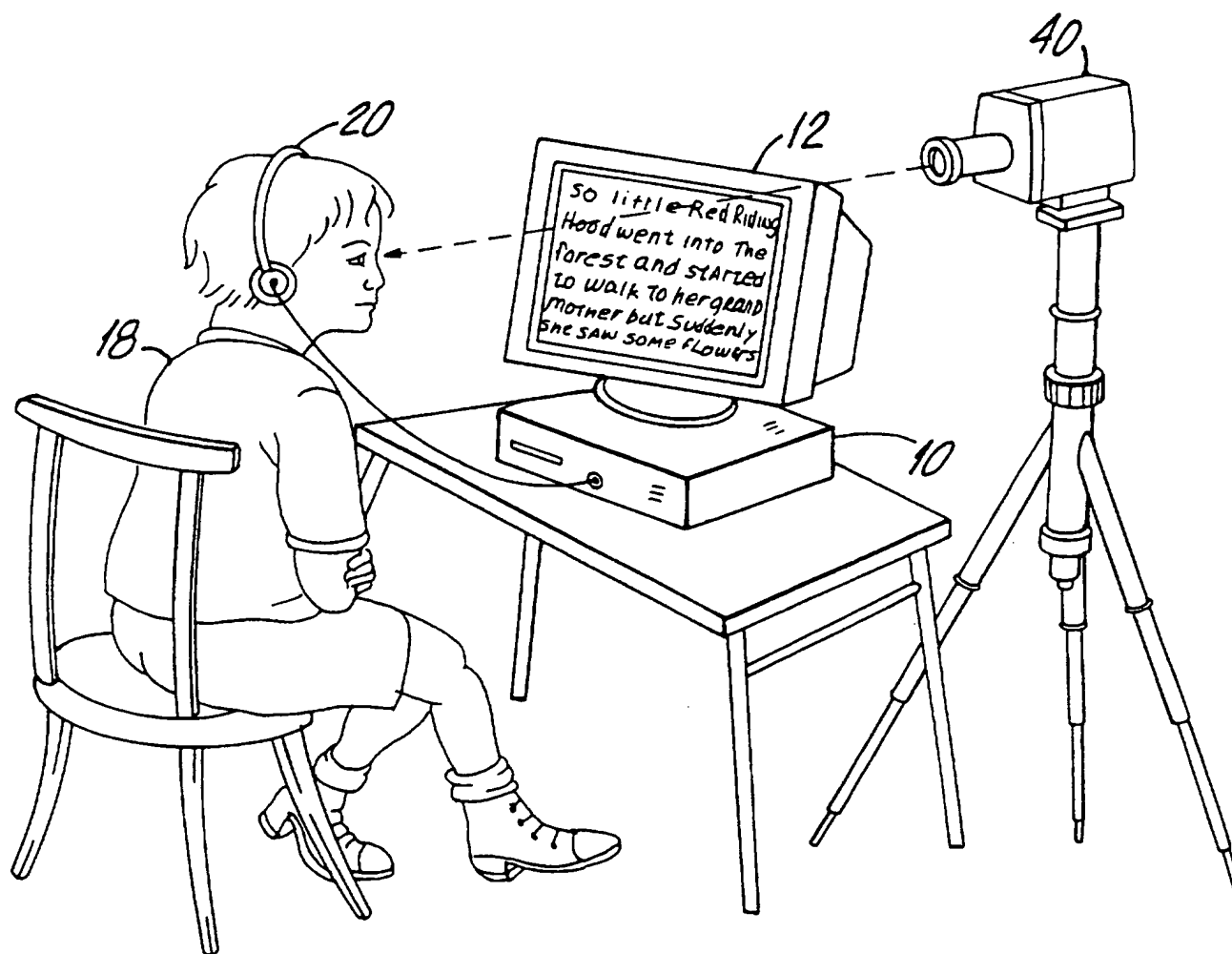24
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- 26 -

So little Red Riding
Hood went into The
forest and started
to walk to her grand
mother but suddenly
she saw some flowers

FIG. 1

FIG. 2

FIG. 3

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6   G09B17/00   G09B5/06   G09B19/06   G11B27/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6   G09B   G11B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	Further documents are listed in the continuation of box C.		X	Patent family members are listed in annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
9 January 1996	15. 01. 96

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